Supervisor's comments to the PhD thesis of RNDr. Kryštof Turba:

Microstructure and mechanical properties of ultra-fine grained materials produced by severe plastic deformation

The PhD thesis is devoted to the experimental study of both commercial Al-7075 and Sc+Zr modified Al-7075 alloys prepared using the method of equal-channel angular pressing. The commercial Al-7075 is known to exhibit superplastic behaviour if prepared with a fine-grained structure using a rather complicated thermomechanical treatment. Unfortunately, the superplastic behaviour of this alloy with the typical grain size close to 10 μm is observed at high deformation temperatures and slow strain rates which reduces the possibility of applications in commercial superplastic forming. A substantial reduction in grain size down to 1 μm or below is believed to result in a shift of superplasticity to higher strain rates and, therefore, in the increase of the potencial for commercial applications. This basic idea was verified in the submitted thesis.

The main objectives of the work were:

- To verify the possibility to use the method of equal-channel angular pressing for the preparation of ultrafine-grained materials based on the Al-7075 alloy (grain size below 1 μm)
- To investigate the microstructure development of these alloys during high temperature exposition and to find out the influence of Sc+Zr addition on the stability of the ultrafine-grained structure
- To study mechanical properties of ultrafine-grained Al-7075 based alloys, especially their superplastic behaviour, and to find out the operating deformation mechanisms

The first part of thesis includes the overview on the methods of severe plastic deformation, especially ECAP, and on the phenomenon of superplastic deformation. This part is very clearly written and documented by an extremely large number of references. It can be used in the future as an excellent up to date background for further investigation.

The thesis was carried out under dual supervision. This made possible to use the experience and experimental equipment of both supervisor's institutes and contributed to a very complex solution of the PhD project. RNDr. Turba utilized a variety of experimental equipments and methods:

- The production of ultrafine-grained materials on the ECAP equipment with the possibility of changing the forming temperature
- The microhardness measurements for the verification of the homogeneity of prepared materials
- The tensile tests both at room and elevated temperatures for the determination of strength characteristics and for the verification of superplastic behaviour

- The transmission electron microscopy for the study of microstructure and its development at elevated temperatures
- The electron backscatter diffractions and orientation mapping tool for the evaluation of the ratio of high angle boundaries in the ECAP materials
- The light microscopy and atomic force microscopy for the investigation of the mechanism of plastic and superplastic deformation of prepared materials

RNDr. Turba employed the above-mentioned methods with success and created a very complex thesis. The experimental results are clearly described and their documentation by a large number of graphs and microstructure pictures is excellent. The range of performed experiments is extremely large, exceeding the usual range of PhD thesis. Thesis does not contain any mistakes or printing errors.

The numerous conclusions drawn from the experimental results are clear and reasonable. Three of them should be especially accentuated:

- The temperature of equal-channel angular pressing influences only slightly the mean grain size. On the other hand, the increase in ECAP temperature contributes to better stability of the ultrafine-grained structure at elevated temperatures.
- The presence of $Al_3(Sc,Zr)$ particles makes possible to maintain the ultrafine-grained structure up to high temperatures. Consequently, excellent superplastic characteristics were observed at very high strain rates. This result is of great importance for the application of the Al-7075 based alloys in commercial superplastic forming.
- The high strength can be achieved in the ECAP material in case that superplastic straining at high temperatures is followed by the T6 precipitation treatment.

RNDr. Turba was during his postgraduate study engaged also in the solution of the GAČR project dealing with the role of grain boundaries in the high temperature deformation of fine-grained materials. He is author or co-author of numerous publications in reviewed journals and contributions on several international conferences.

It can be concluded that both the extremely high standard of thesis and numerous further activities demonstrate that RNDr. Turba is a complete scientist. I would like to recommend to accept the thesis submitted by RNDr. Kryštof Turba as a PhD thesis and to award his work by the title „doctor of philosophy, PhD."

Prague, 8.10.2009

Doc. RNDr. Přemysl Málek, CSc.

Supervisor